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MEALY BUGS OF CITRUS TREES

BY

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MEALY BUGS OF CITRUS TREES*

By CURTIS P. CLAUSEN

INTRODUCTION

Among the pests of citrus trees in Southern California, the mealy bugs are of considerable importance. This is particularly true in the coastal regions, where conditions of humidity and temperature are most favorable to the maximum development of these pests. To this susceptibility to climatic influences may be attributed, in part, the comparative slowness of the spread of these pests over the citrus section and their restriction to the coastal tier of counties, thirty-five years after the time of their first introduction. In the interior sections the increase in numbers is not nearly so rapid and it is only in occasional instances that an infestation becomes serious enough to require extensive control measures. While in the aggregate the damage caused by these pests is much less than that done by the so-called true scale insects, yet in particular cases the injury inflicted has resulted in a considerable loss of fruit and in an extensive dropping of foliage.

SPECIES CONCERNED

The total number of mealy bug species occurring in Southern California is about twenty, and the list of host plants upon which these occur is large and varied. The species discussed in this paper comprise only those found generally, wherever they occur, upon citrus trees. They are the common mealy bug (*Pseudococcus citri* Risso), Baker's mealy bug (*Pseudococcus bakeri* Essig), the citrophilus mealy bug (*Pseudococcus citrophilus* Clausen MSS), and the long-tailed mealy bug (*Pseudococcus longispinus* Targ.). Occasional specimens of other species, such as *P. ryani* (Ckll.) and *Ceroputo arctostaphylii* (Colm.), have been found upon citrus trees, but their presence there may be considered as accidental. Laboratory experiments have borne out the assumption that they exist only for a comparatively short time solely upon either the foliage or the fruit of the citrus tree. Separate discussions of the life history and habits of the different species will be given in the order of their importance as citrus pests at the present time.

* Paper No. 5, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

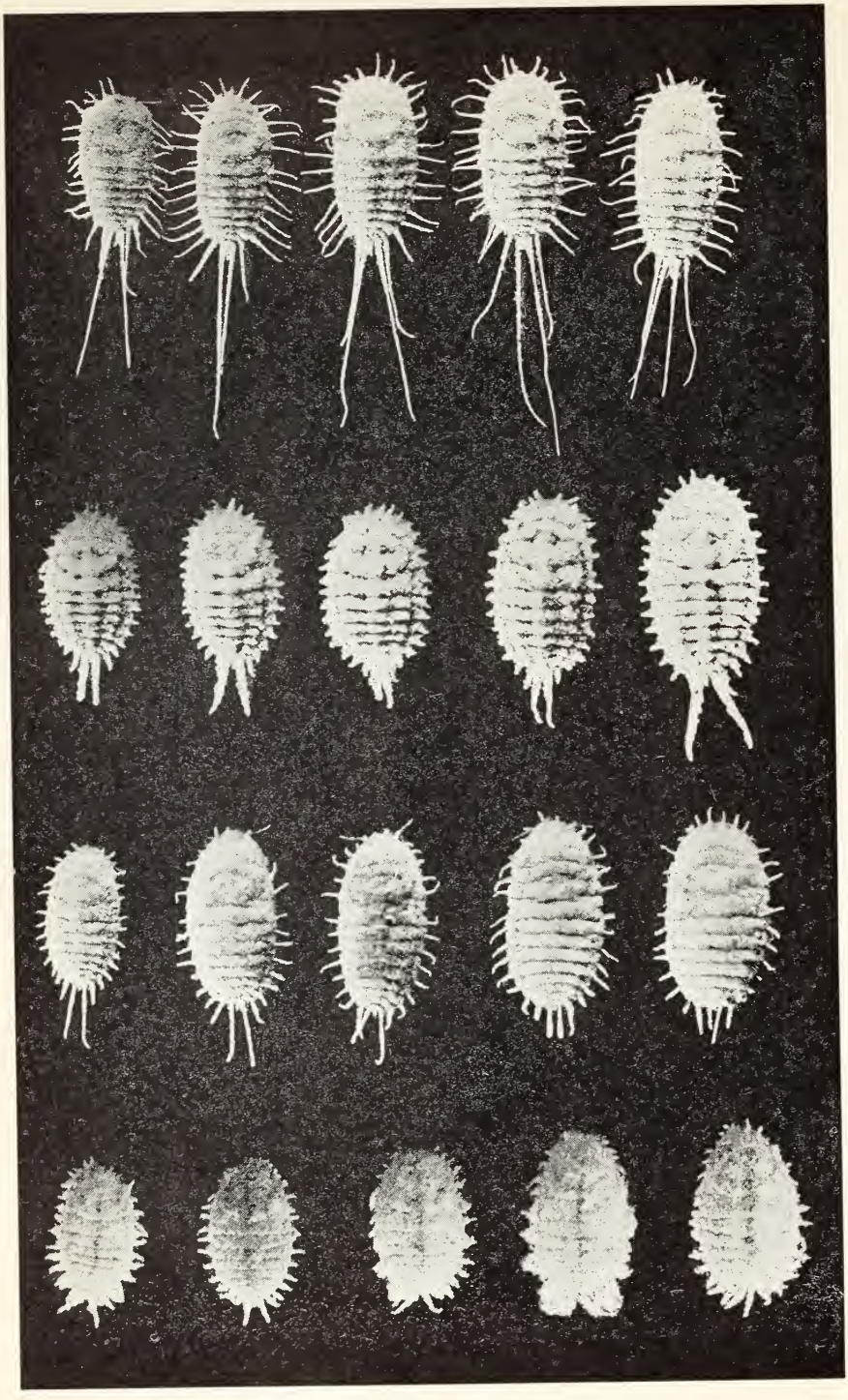

Fig. 1.—Mealy bugs of citrus trees. *A.* The long-tailed mealy bug (*Pseudococcus longispinus*). *B.* The citrophilus mealy bug (*Pseudococcus citrophilus*). *C.* Baker's mealy bug (*Pseudococcus bakeri*). *D.* The common mealy bug (*Pseudococcus citri*). Enlarged 7 diam.

GENERAL DESCRIPTION

The mealy bugs are characterized by the possession, in the females, of a more or less dense waxy or cottony covering, ordinarily white in color, extending over the entire upper surface and in most cases the lower surface also. The lateral margin of the body bears upon each segment a filament of this same material, which arises from or is secreted by glands grouped about spines of greater or less length. This covering, with the attendant lateral filaments, is secreted by the individual after each moult, the body of the larva being entirely devoid of protection immediately following the casting of the skin, or exuvium. The general appearance of the larva is very similar to that of the adult.

The male, in its early stages, greatly resembles the female, but when it is about one-fifth the length of the adult female it forms a fibrous, cottony cocoon about one-eighth of an inch long, within which a transformation takes place and from which the adult male emerges as a small two-winged insect of very delicate structure.

With the exception of the male pupa, all stages of this insect following the newly hatched young are mobile, and movement from place to place may be observed very frequently.

While *P. longispinus* produces its young alive, the species previously named deposit their eggs in fairly compact ovisacs, which do not envelop the female. These egg masses, when grouped together in great numbers, produce the cottony masses which are so conspicuous upon the fruit, and to a lesser degree upon the foliage, wherever a serious infestation of this insect occurs.

THE COMMON MEALY BUG

(*Pseudococcus citri* Risso)

General Account.—This species is by far the most injurious member of this group of insects and in the aggregate the amount of damage done exceeds that done by all other members of the genus. Over small areas it is as serious a pest as any of the scale insects known to infest citrus trees and is more difficult to control. Considering the entire citrus district of Southern California, however, this pest probably ranks sixth in the total amount of damage done, being preceded by the black, the red, the purple, the citricola, and the yellow scales in the order given.

For many years this insect has been a more or less serious pest in Florida. Though data relative to its introduction into California is

very meager, information from the most reliable sources available places the date thereof at about 1880 and the place San Diego County. Introduction into Ventura County[1] took place through nursery stock during the season of 1897, though it was not until 1908–09 that the infestation assumed alarming proportions. The year 1909 marked the height of one of the periods of heavy infestation by this species, but since that time the damage done has not been so great. This general decline in destructiveness cannot be attributed entirely to the control measures employed for the reason that badly infested groves not treated in any way are now as free from the pest as those in which control measures were employed.

Nature of Injury.—The injury done by the citrus mealy bug consists of a general withdrawal of sap from the twigs and fruit, the smutting and subsequent dropping of the foliage, and a discoloration and retardation of growth in the fruit. At the time of blossoming a general dropping of the flowers and newly set fruit often takes place where the young mealy bugs assemble in large numbers in the calyx cup, killing the plant tissue at the base of the embryo. The larvae may also appear in large numbers upon the foliage, withdrawing sap and chlorophyl from the cells and thus preventing the proper functioning of the leaves. The smutting of the foliage is very extensive, the mealy bugs in all the larval stages exuding large quantities of "honeydew", in which the black sooty mould fungus, *Meliola camelliae* (Catt.) grows. This may be so great as to cause more or less defoliation of the trees. Quayle[2] reports this condition as very general in the citrus districts of Sicily during the year 1913.

One of the marked habits of this species is the tendency of the larvae and adults to assemble in large, compact groups upon the fruit and branches. In the case of oranges this causes a delay in the color ation of that area of the fruit, though in some instances an unnatural reddish color is produced in the affected areas. As far as could be determined, this unnatural coloration was not due to the presence of a fungus, but probably to some change of the cells caused by the feeding of the mealy bugs. The effect is also particularly severe upon navel oranges, where large masses of eggs are found in the navel end, which often bring about a rapid decay of this portion of the fruit. The effect upon lemons, aside from the distortion of the fruit in the younger stages, is an unevenness in coloration and premature ripening. The large and conspicuous egg masses upon the fruit give it a very

[1] Essig, E. O., P. C. Jour. Ent., Vol. II, No. 4, p. 289, December, 1910.

[2] Quayle, H. J., Citrus Fruit Insects in Mediterranean Countries, U. S. D. A., Bull. 134, p. 21 (1914).

unsightly appearance, and the presence of these adds greatly to the difficulty of controlling the insect.

In the case of young trees, and also in that of older trees that have been rebudded, much damage is often done by the massing of the mealy bugs upon the young and tender shoots. Often these shoots are completely killed, necessitating the expense of rebudding. On young trees the injury is rarely severe enough to require the replacement of the tree.

In California the distribution is general over the entire state, though in the northern part the infestation is limited largely to green-

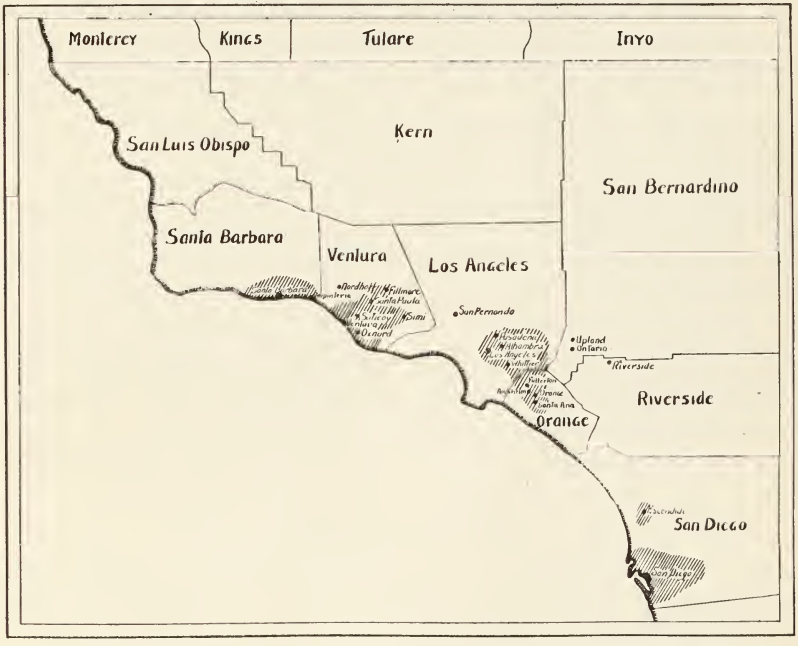

Fig. 2.—Map indicating distribution of common mealy bug (*Pseudococcus citri*) in Southern California

houses and to certain ornamental trees. In the citrus sections of Butte and Yuba counties, however, some trouble has been experienced from the attacks of this insect. In Southern California the infestation of this pest on citrus trees is confined to Santa Barbara, Ventura, Los Angeles, Orange, and San Diego counties. It occurs elsewhere upon ornamental plants and in greenhouses. In Santa Barbara County, where conditions are apparently satisfactory for the maximum development of the pest, no instance of a severe infestation upon an extensive scale has been reported, and a recent inspection of the district by the writer resulted in the finding of the pest very generally

on ornamental plants and occasionally on citrus trees, but no cases were noted in which serious damage had been done in commercial groves. In Ventura and Los Angeles counties a wide distribution exists and a number of groves are at present suffering from the attacks of this pest, though as a whole the damage done is less than that of 1909–10.

Host Plants.—Because of its general distribution over the world, the recorded host plants of this species are numerous and of widely different forms. A list, though manifestly incomplete, is here given:

Asparagus (*Asparagus officinalis*)
Bird of Paradise flower (*Strelitzia gigantea, regina*)
Bottle-brush (*Callistemon lanceolatus*)
Bouvardia sp.
California laurel (*Umbellularia californica*)
Cestrum sp.
Citron (*Citrus medica* var. *genuina*)
Coffee (*Coffea Arabica*)
Coleus (*Coleus Blumei*)
Columbium sp.
Cotton (*Gossypium peruvianum*)
Cranesbill (*Geranium* sp.)
Cucumber (*Cucumis sativus*)
Deer-brush (*Ceanothus integerrimus*)
Dracaena (*Cordyline terminalis*)
English ivy (*Hedera helix*)
Ferns
Fuchsia (*Fucshia* sp.)
Grape (*Vitis vinifera*)
Granadilla (*Passiflora edulis*)
Jasmine (*Gardenia jasminoides*)
Leadwort (*Plumbago* sp.)
Lemon (*Citrus medica* var. *limon*)
Magnolia (*Magnolia grandiflora*)
Moonflower (*Ipomoea Bona-nox*)
Nettle (*Urtica urens*)
Nightshade (*Solanum douglasii*)
Oleander (*Nerium oleander*)
Orange (*Citrus aurantium*)
Panax monstrosa
Peony (*Paconia* sp.)
Pepino (*Solanum muricatum*)
Phyllanthus carolinensis
Poinsettia (*Euphorbia pulcherrima*)
Pomelo (*Citrus decumana*)
Potato (*Solanum tuberosum*)
Potato vine (*Solanum jasminoides*)
Pumpkin (*Cucurbita pepo*)
Purple passion-flower (*Passiflora violacea*)
Redwood (*Sequoia sempervirens*)
Rex begonia (*Begonia* sp.)
Tacsonia jasminoides
Tobacco (*Nicotiana tabacum*)
Umbrella-plant (*Cyperus alternifolius*)
Variegated wandering-jew (*Zebrina pendula*)

Among those given, the coleus, various species of citrus, nightshade, and potato vine may be mentioned as preferred hosts.

LIFE HISTORY

The Eggs.—The eggs are deposited by the female upon the fruit, on the twigs and foliage, and under loose pieces of bark, etc. They are enclosed in a fairly compact network of interwoven fibers, giving the general appearance of a light, cottony mass. The formation of these egg masses in large numbers upon the fruit gives rise to the large clusters, observed so generally upon badly infested trees.

The number of eggs deposited by a single female ranges from 300 to 587, as determined from 21 individuals, the average being 483 eggs. The time required for oviposition varied from 6 to 14 days under normal summer temperatures. During the cooler portions of the year this period will be greatly lengthened. Hatching takes place from 6 to 10 days after the eggs are laid, though during the winter months several weeks may be required.

Proportion Hatching and Degree of Larval Mortality.—Complete hatching records of 4000 eggs give the proportion hatching as 91 per cent. During the early larval stages the number dying from various causes, including parasitic and predaceous enemies, is very great. In all probability the number ultimately reaching maturity even in cases of very serious infestation will not exceed 10 per cent of the whole number.

The Female.—The newly hatched larvae are light yellow in color and devoid of any waxy covering, which, however, soon appears. The periods of time covered by the three larval stages in 24 individuals were 15, 16, and 16 days respectively. Egg laying begins approximately two weeks after the third and final moult, and death takes place as soon as oviposition is completed.

The Male.—During the early stages very little distinction can be found between the males and females. The formation of the cocoon is begun about four weeks after hatching and the adult male emerges 10 to 14 days later.

SEASONAL HISTORY

There is very little differentiation in time of appearance between succeeding generations in this species, though the development in the late winter and early spring is quite uniform. This condition, however, disappears very soon, the variation in the development of the individuals being so great as to cause a complete merging of succeeding generations, so that during the summer and fall months all stages may be found upon the tree in large numbers. The mealy bug passes the winter upon the tree in all stages, though the larger proportion are in the egg stage. The eggs are laid by females developing slowly and irregularly during the late fall and winter months and remain for a considerable time without hatching. In San Diego County great masses of adults and eggs have been observed clustered upon the trunk of the tree from the surface of the ground to six inches below. Sufficient numbers, however, were present upon the fruit and foliage to give a thorough and rapid start in the spring. When warm weather

appears the eggs hatch in great numbers and the larvae assemble upon all fresh growth, particularly upon young fruit, buds, and sucker growths. It is at this time that much injury is done by the attacks upon the blossoms, causing a marked dropping of these, and of the newly set fruit as well. In the case of fruits partially developed before the infestation becomes severe, a considerable distortion may be brought about because of the bugs massing upon them and preventing their proper development. The spring attack is usually at its worst from April to June. Thereafter the high summer temperature is apparently not conducive to the maximum development. The fall infestation appears during early September, and this infestation as it develops during the succeeding months is the more severe of the two.

BAKER'S MEALY BUG

(*Pseudococcus bakeri* Essig)

General Account.—This mealy bug was first described from Santa Paula, California,[3] where it was reported as occurring generally upon the walnut, apple, and pear trees grown in the citrus section of Ventura County. It was first collected, however, upon the elder (*Sambucus glauca*), which grows abundantly in the waste areas in the vicinity of Santa Paula. The great number and variety of its host plants and its distribution generally over the state give considerable support to the belief that it is a native species. Up to the time above noted, however, no record had been made regarding its occurrence upon citrus trees, and the fact that it has become a general citrus tree feeder indicates possibilities along this line in the case of other species.

Distribution.—The range of distribution of this species is constantly widening, and a thorough determination of its limitations will undoubtedly reveal it in many sections now supposedly uninfested. The writer has found it upon citrus trees in Santa Barbara, Ventura, Los Angeles, Orange, and San Diego counties, and upon native and ornamental plants in Riverside and in San Bernardino counties. It was also observed upon a variety of plants in the Botanical Gardens at Berkeley and has been reported from that place upon the walnut and upon the California buckeye.[4] The distribution, therefore, as far as is now known, occurs over the northern and central parts of

[3] Essig, E. O., P. C. Jour. Ent., Vol. II, No. 4, pp. 239–246, December, 1910.

[4] Childs, Leroy, Monthly Bulletin Cal. Hort. Com., Vol. III, No. 5, p. 220, May, 1914.

the state and generally over Southern California, with the exception of the Imperial Valley.

Nature of Injury.—The injury occasioned to citrus trees is not important and differs in no marked degree from that produced by a light infestation of the common mealy bug. The full-grown larvae and adults in many cases under observation showed a strong tendency to confine their feeding to the young and more succulent branches, and they clustered in considerable numbers in the crotches of the small branches. Where fruit is present, however, many mealy bugs in all

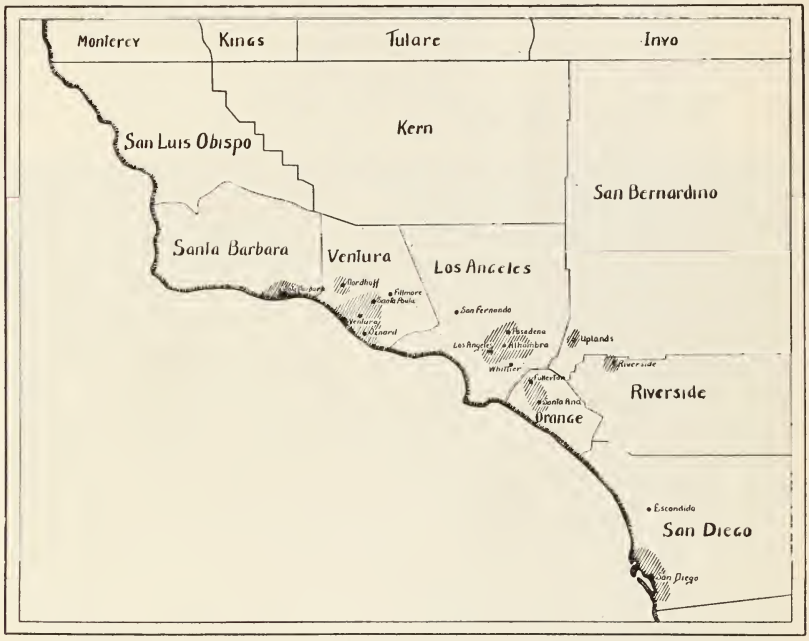

Fig. 3.—Map indicating the distribution of Baker's mealy bug (*Pseudococcus bakeri*) in Southern California

stages may be found in the navels, under the calyx lobes, and at the point of contact of fruits. (See fig. 5.) Thus far no infestation has been found where the injury to the fruit or tree was serious enough to require control measures.

Host Plants.—The number and variety of host plants fostering this species is large, rather incomplete determinations comprising the following list. The elder, walnut, and umbrella plants may be termed preferred hosts, though this is quitely largely dependent upon the conditions under which they are grown.

Apple (*Pyrus malus*)
Buckeye (*Aesculus californica*)
California laurel (*Umbellularia californica*)
Candlenut (*Aleurites triloba*)
Century plant (*Agave Americana*)
Coleus (*Coleus Blumei*)
Cestrum (*Cestrum elegens*)
Dracaena (*Cordyline terminalis*)
Elder (*Sambucus glauca*)
English ivy (*Hedera helix*)
Enterolobium sp.
Horseweed (*Erigeron canadensis*)
Iris (*Iris douglasiana*)
Japanese quince (*Cydonia japonica*)
Lemon (*Citrus medica* var. *limon*)
Lemon lily (*Lilium Parryi*)
Lima bean (*Phaseolus lunatus*)
Mexican orange (*Choisya ternata*)
Nettle (*Urtica urens*)
Nightshade (*Solanum douglasii*)
Orange (*Citrus aurantium*)
Pear (*Pyrus communis*)
Potato (*Solanum tuberosum*)
Potato vine (*Solanum jasminoides*)
Silk oak (*Grevillea robusta*)
Walnut (*Juglans regia*)
Wild sunflower (*Helianthus annuus*)
Willow (*Salix* sp.)
Windmill palm

Fig. 4.—Baker's mealy bug (*Pseudococcus bakeri*) congregated at the point of contact of two fruits

LIFE HISTORY

The Egg.—The eggs of this species are very similar in general appearance to those of the common mealy bug and are laid in egg-sacs measuring one-fifth to one-third of an inch in length. The number deposited by a single female ranged from 432 to 621 in the 32 individuals under observation, the average being 547 eggs. The time in

Fig. 5.—A cluster of dates infested by Baker's mealy bug

days over which egg laying extended ranged from 7 to 15, with an average of 10.3 days. The daily average would, therefore, be approximately 53 eggs. The period of incubation is about eight days during the summer and considerably longer during the cooler portions of the year.

The Female.—The larvae at the time of hatching are devoid of all waxy covering, but its secretion is soon commenced. At the end of the second stage the wax filaments approximate in length those of the adult and the body color now becomes the typical slate gray of the older forms. The time required for the different stages is quite variable, but the records of 21 individuals gave 16.3, 13, and 13 days respectively. Egg-laying commences several weeks after the final moult, the females in the meantime having grown considerably, the maximum length being about one-fourth of an inch.

The Male.—The formation of the cocoon begins from one to two weeks after hatching, the early larval stages previous to this time being very similar to those of the female. The period of time passed within the cocoon is about nine days, at the end of which time the adult male emerges.

THE CITROPHILUS MEALY BUG

(*Pseudococcus citrophilus* Clausen MSS)

General Account.—During the fall of 1913 there was discovered in a restricted locality near Uplands, California, an infestation of mealy bugs in a number of groves. On the basis of no definite determinations of the specific identity of the insect, it was assumed by the growers to be the common mealy bug (*P. citri*), and much alarm was felt by the growers over the unexpected invasion of this pest into the interior valley, where it supposedly would not thrive because of adverse climatic conditions. Much damage was done to certain groves in a hasty attempt to eradicate the pest, the loss being estimated at approximately $15,000. In order to secure more accurate and reliable information as regards ways and means of control, an Emergency State Fruit Growers' Convention was called at Ontario, California, January 30, 1914, at which time extended discussions were given by growers and investigators upon the various phases of the problem, referring mainly, however, to the common mealy bug (*P. citri*). Specific determinations made at this time indicated that the insect was Baker's mealy bug (*P. bakeri*), a native species known at that time to occur only in Ventura County, where it was present on many wild plants and to a limited extent upon citrus trees. The particular differences in characters which led to the determination of the Uplands form as a new species will be discussed in a later publication.

Nature of Injury.—The actual damage thus far produced has not been great, though the loss entailed by attempted eradication was con-

siderable. In the worst infested groves, a slight dropping of the flowers and young fruit upon lemon trees was noticeable, and also a smutting of the tree during the early spring and summer months. Some discoloration of oranges was observed and an occasional infection of the navel end brought about by the mealy bugs clustering therein, but this condition was not extensive. The habit of gathering in large clusters, so characteristic of the common mealy bug, is almost entirely absent in this species, thus eliminating to some extent the large egg masses upon the fruit, such as are so noticeable in the case of an infestation of the former species.

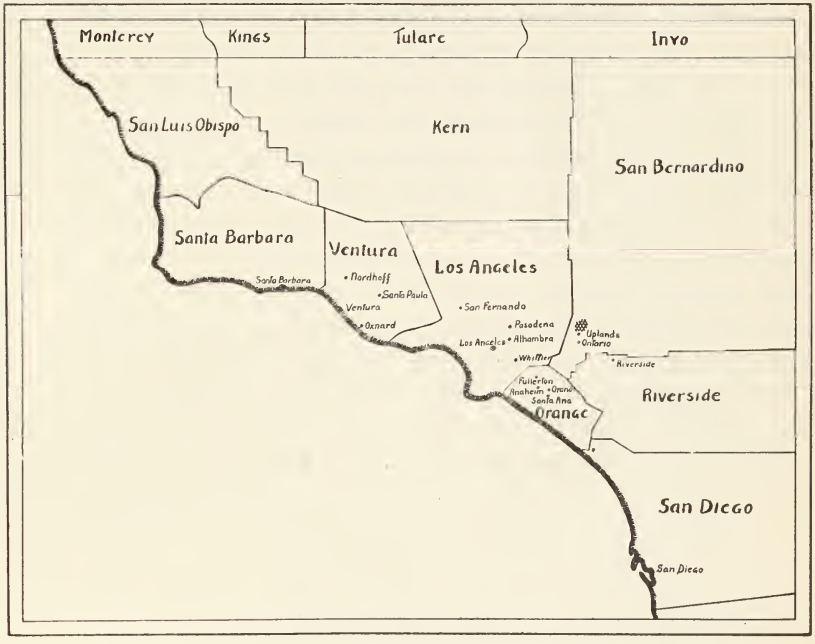

Fig. 6.—Map showing distribution of citrophilus mealy bug (*Pseudococcus citrophilus*) in Southern California

General Description.—A comparison of this form with typical specimens of Baker's mealy bug from Ventura showed a considerable difference in general appearances, and led to the belief that possibly the infestation at Uplands was by an entirely different species, rather than by the one occurring upon citrus trees in Ventura County. These differences, in connection with several structural characters, ultimately led to the determination of this form as a new species.

In the case of Baker's mealy bug, the fine waxy secretion is evenly deposited over the entire surface of the body, while the lateral filaments are of a delicate, thread-like appearance and averaging not more than one-fourth the width of the body. The caudal filaments

are of the same general form but longer, being from one-third to one-half the length of the body. As contrasted with this, the citrophilus mealy bug presents a decidedly different appearance, the waxy covering of the body being of a much more granular texture and deposited unevenly over the surface.

A detailed description of this species is now in course of preparation and will shortly be available for those desiring to make a more technical study of its taxonomic characters.

Distribution.—This species, on the basis of our present knowledge of its habits and distribution, is strictly limited to a district of approximately one square mile in area, near Uplands, California. The infestation has spread considerably since its discovery in 1913, the number of groves in which the pest can now be found being nearly twice the number determined at that time.

Origin of the Infestation.—All clues bearing upon the introduction of this pest have failed to give any positive information as to either the time or source of the original importation. During the year 1910 a considerable number of imported ornamental plants were brought in and planted near the center of the present infested area. These plants, according to the horticultural inspector of that district, were not examined, and the presence or absence of pests upon them at that time cannot, therefore, be determined. The infestation seems to have spread quite uniformly from this central point, and the assumption of these growers that the insect was brought in upon certain of these plants is, in the absence of positive evidence to the contrary, fairly logical. That it is an introduced species seems to be established with a considerable degree of certainty, and a study of its rate of increase and methods of dispersion have lead to the conclusion that the year 1910 marks approximately the time of introduction.

Host Plants.—In so far as they have been determined, the host plants of this species are confined to the following series:

Azalea (*Azalea* sp)
Blackberry (*Rubus villosus*)
Climbing fig (*Ficus pumila*)
English Ivy (*Hedera helix*)
Fig (*Ficus carica*)
Heliotrope (*Heliotropium* sp.)
Lemon (*Citrus medica* var. *limon*)
Mallow (*Malva parviflora*)
Mexican orange (*Choisya ternata*)
Mustard (*Brassica nigra*)
Nightshade (*Solanum douglasii*)
Orange (*Citrus aurantium*)
Pepper tree (*Shinus molle*)
Pigweed (*Chenopodium album*)
Potato (*Solanum tuberosum*)
Raspberry (*Rubus nutkanus*)
Rhubarb (*Rheum rhaponticum*)
Rose (*Rosa* sp.)
Rye grass (*Lolium perenne*)
Silk oak or Grevillea (*Grevillea robusta*)
Sweet Clover (*Melilotus alba*)
Sunflower (*Helianthus annuus*)
Walnut (*Juglans regia*)

It must be remembered in connection with the list of host plants, however, that these in every case were closely adjacent to infested citrus trees, and individuals upon these plants do not necessarily indicate that the complete life cycle could be accomplished solely upon this particular host. The infestation was particularly severe upon the grevillea, rhubarb, and potato, even more so, in fact, than upon nearby citrus trees. Potato vines were in many cases completely killed, the mealy bugs becoming thickly massed upon the stems and upper roots, and in some cases extending even down upon the tubers themselves. Upon the grevillea, in the early spring particularly, the young bugs were commonly found densely clustered about the base of newly developing shoots. Later in the season their activities were confined largely to the tender growth upon the margins of injured areas and upon other more succulent areas. Rhubarb grown in the immediate vicinity of infested trees was very severely attacked, the insects being densely massed upon the leaves, petioles, and also, to a considerable extent, upon the tubers below the surface of the ground.

LIFE HISTORY

The Egg.—The number of eggs deposited by a single female is somewhat greater than in the other species discussed, the range being from 394 to 679 for the entire period, averaging 533 eggs for 40 individuals. Upon a daily basis, this represents 62 eggs, though in one instance 127 eggs were deposited by a single female. The period of oviposition ranges from seven to ten days under normal conditions.

The Female.—The larvae at the time of hatching are about one-fortieth of an inch in length and yellow in color, though this changes to a deep amber in the later stages. The three moults take place at intervals of 15, 13, and 12 days respectively. In all respects except that of size, the larvae after the second moult are similar to the adults. Previous to this time the ridged appearance is noticeable to a certain extent, and also the long caudal filaments. During the adult stage occasional individuals are almost entirely devoid of the waxy covering on the upper surface.

The Male.—The formation of the cocoon is begun by the larvae about twenty-five days after hatching, and the adult male emerges nine to eleven days later.

SEASONAL HISTORY

The first generation of any size during the spring of 1914 hatched during March and reached maturity the latter part of April. Oviposition took place generally during the month of April, and the

second generation, of considerable size, began to appear about the first of May. The numbers were very great at this time, and shortly afterwards a slight dropping of the young fruit was noticed, due to the clusters of young mealy bugs in the calyx cup. A considerable blackening of the interior foliage of the lemon trees was apparent. The marked migratory habit of the females was also observed at this time. This generation reached maturity during the early part of June. In numbers of adults present, this was the largest generation of the year, the summer heat following shortly afterwards apparently having the effect of killing off many of the individuals in the younger stages.

Fig. 7.—Grevillea trees topped in an effort to prevent the spread of the citrophilus mealy bug (*P. citrophilus*)

The third generation appeared in adult form during the latter part of July and the first week in August. From July 10 to 20 very few mature females and egg masses could be found, and this was in many ways the most distinct generation of the year. In contrast with those of the second generation, the females were considerably reduced in size, due perhaps to the extreme heat.

The limits of the fourth generation, while noticeable, were not as distinct as those of the two previous generations. A considerable decrease in numbers was observed. The adults appeared in greatest numbers about the first of October, and oviposition took place irregularly after this time.

No distinction in generations could be determined from this time on, and upon the citrus, development was greatly inhibited, to a considerable extent at least. All stages, however, could be found upon the fruit throughout the winter, though the adult females were very scarce. First and second stage larvae were found in considerable numbers in the depressions on the surface of the fruit. In contrast to this, on the grevillea trees bordering the infested groves a large proportion of those found were in the adult stage, though oviposition was not general. Upon rhubarb the infestation throughout the winter was very heavy, upon the leaves as well as upon the roots. None were found upon the roots of citrus trees.

The most noticeable feature of the seasonal history of this species, and in marked contrast to that of those previously discussed, is the remarkable distinctness of the generations throughout the major portion of the year, and this feature is of considerable value in the determination of methods of control and the time of application. Whether this will hold when an infestation becomes very severe remains to be seen, but under present conditions this characteristic holds true to a marked degree.

THE LONG-TAILED MEALY BUG

(*Pseudococcus longispinus* Targ.)

General Account.—Among the most common of the greenhouse pests will be found usually the long-tailed mealy bug, so termed because of its unusually long caudal filaments, these often being much longer than the body. While not occurring to any extent upon citrus trees, it is often found upon those growing in sheltered and protected places, and for this reason would be classed among the citrus pests of this group.

Distribution.—This species is a common pest in nearly all of the tropical and subtropical regions of the world, and also in greenhouses in the colder countries. In Southern California it has been found in Santa Barbara, Ventura, Los Angeles, Orange, and San Diego counties. It has also been found on nursery stock in Riverside and San Bernardino counties, which had previously been brought in from other sections. To the writer's knowledge, however, no general nursery infestations are present in these two counties. Its presence upon the citrus trees is confined largely to the coast counties, particularly Santa Barbara and Ventura.

DISTRIBUTION CHART

Host Plants.—The list of host plants of this species indicates that it is a general feeder upon most greenhouse plants, and also upon a considerable number growing in the open. The following series comprises the complete list as previously published, and also those determined by the writer.

Begonia (*Begonia* sp.)
Bird of Paradise flower (*Strelitzia gigantea*)
Calla (*Rhicardia Africana*)
Candlenut (*Aleurites triloba*)
Century plant (*Agave Americana*)
Cineraria (*Cineraria cruenta*)
Citron (*Citrus medica* var. *genuina*)
Coleus (*Coleus Blumei*)
Crab cactus (*Epiphyllum* sp.)
Croton (*Croton Tiglium*)
Damolya spectabilis
Dracaena (*Cordyline terminalis*)
Ferns
Fig (*Ficus carica*)
Flacourtia sepiaria
Fuchsia (*Fuchsia* sp.)
Guadalupe Island palm (*Erythea edulis*)
Guava (*Pisdium guajava*)
Lemon (*Citrus medica* var. *limon*)
Mango (*Mangifera Indica*)
Moonflower (*Ipomoea Bona-nox*)
Nephrodium amplum
Oleander (*Nerium oleander*)
Prickly pear (*Opuntia* sp.)
New Zealand Flax (*Phormium tenax* var. *variegatum*)
Plum (*Prunus domestica*)
Primrose (*Primula obconica*)
Sago palm (*Cycas revoluta*)
Staghorn ferm (*Platycerium* sp.)
Stangeria schizodon
Sterculia gregori
Umbrella-plant (*Cyperus alternifolius*)
Zamia sp.

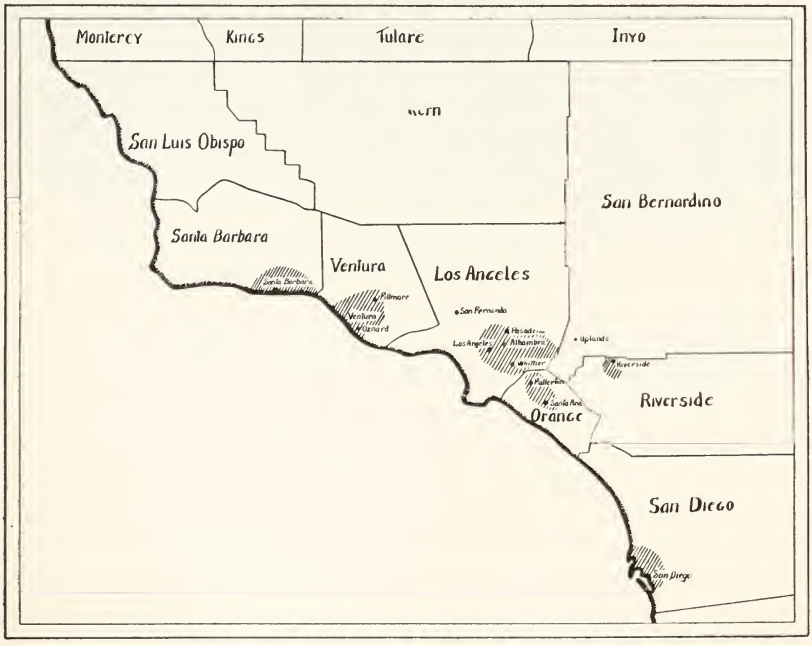

Fig. 8.—Map indicating distribution of the long-tailed mealy bug (*P. longispinus* Targ.)

In the coast counties particularly the Dracaenas under normal outdoor conditions are very heavily infested, thereby rendering them unsightly and of little value for ornamental purposes. In some cases a complete killing of the plant is brought about. The mealy bugs cluster thickly on the under sides of the leaves and at the base of the growing portion of the top. In the greenhouses the growing tips of the plants often become so thickly covered with the young mealy bugs as to seriously retard growth, or to cause the death of the plant.

A number of the host plants as above enumerated were found only in ornamental gardens and are of rare occurrence in this region, being largely tropical plants imported in very limited numbers.

LIFE HISTORY

Manner and Rate of Reproduction.—Unlike the species previously considered, this mealy bug deposits no eggs, but reproduces itself by means of the production of living young. The female, therefore, forms no egg-sac, but merely secretes about her body a thinly woven cottony network, within which the young are born and sheltered for a time before feeding begins. Considerable difficulty was experienced in securing the rate of larvaposition, due to the disturbing effect upon the female occasioned by the daily removal and counting of the young. Records of 15 individuals, kept through the entire adult period, gave a range in the length of the period of larvaposition of from 10 to 21 days, averaging 15.8 days. The largest number of young produced by a single female in one day was 37, and for the entire period 321 young. The totals for all specimens averaged 206, which, when reduced to a daily basis, represents 13 young per day. From this it will be seen that the rate of increase is considerably slower than in any of the preceding three species, the progeny of one individual numbering less than half that of the common mealy bug (*P. citri*) and somewhat more than one-third that of the citrophilus mealy bug (*P. citrophilus*).

Mortality in Various Stages.—It was found that the mortality during the first larval period was far greater in this species than in any of the three species previously discussed. The young, remaining clustered under the body of the parent for one or more days after birth, are well protected from sudden changes of the various climatic conditions, but after their emergence from this protection the death rate is greatly increased. After this first larval period, the mortality may be termed normal as compared with that of the other species. There being none of the large egg masses present, the opportunity

for extensive work by predaceous enemies is somewhat lessened, though the number and effectiveness of internal parasites is slightly greater.

The Female.—The periods of time required for the different stages were decidedly variable, the first being completed in from 10 to 20 days after birth; the second, 8 to 22 days later; and the third, 7 to 20 days afterwards. The averages of these periods for all individuals under observation were 16.5, 15, and 12.5 days respectively. Fertilization takes place largely during the third larval period, and larva-position begins within 10 to 15 days after the casting of the third larval skin.

SEASONAL HISTORY

No particular distinctions between generations can be found at any time of the year. Reproduction naturally is more rapid during the warmer months than during the winter, and the infestation is usually at its height during the fall months. From January to March the production of young is inhibited by adverse climatic conditions, but this period is so short as to cause no appreciable diminution in the infestation.

PARASITES AND PREDACEOUS ENEMIES

It is not proposed to give here an extended and detailed discussion of the mealy bug parasites of California, this being reserved for a later paper. The various enemies here considered are given in the order of their relative value as mealy bug destroyers, though aside from the first five their occurrence is so limited as to make an accurate study of their comparative efficiency impossible.

The Brown Lacewing (*Sympherobius californicus* Banks).—This lacewing is by far the most effective of the entire series of mealy bug predators. Its distribution is quite general throughout the entire infested area, though at Uplands, California, it is found only very occasionally in connection with the infestation of *P. citrophilus.* The eggs are pearly white in color, and are deposited by the female upon the surface of the fruits and leaves or within the egg masses of the host. Several cases were observed where the egg was laid directly upon the body of the live mealy bug. The larvae, upon emergence from the eggs, immediately move about in search of food. The adults are also very active feeders upon the younger stages of the mealy bug, though the number consumed is not nearly so great as by the larvae in the later stages. The adult life extends normally over a period of from one to three weeks.

Preying upon the immature stages of this lacewing and greatly reducing its effectiveness is a small hymenopterous parasite (*Isodromus iceryae* How.), which deposits its egg within the body of the larva and brings about its death after pupation has taken place.

Leucopis bella Loew.—This small fly is found in comparatively large numbers in practically all sections infested with the mealy bug, and is the only enemy of *P. citrophilus* of any importance. The egg is pearly white in color, oblong in form, quite strongly pointed at one end, and bears upon the surface delicate longitudinal ridges. These eggs are deposited by the fly singly upon or under the egg masses, and the young at the time of hatching commence feeding upon the eggs and newly hatched larvae of the host. In the case of the more mature individuals, instances have been noted in which the larva attached itself to the body of an adult mealy bug, though apparently unable to bring about its death. The cocoons are formed either within the egg masses or in various protected places, a favorite position being under fragments of loose bark or in dried or curled leaves.

Cryptolaemus montrouzieri Muls.—Much has been claimed for this coccinellid as a natural enemy of the mealy bug in southern California since its introduction into the state by Alfred Koebele some time between 1890 and 1895. In 1909 it was introduced into Ventura County and during the following season was reported to have done remarkable work. At present only occasional specimens can be found, even in heavily infested groves, and there is little reason to believe that this parasite is in any very large measure responsible for the general decline in the severity of the mealy-bug infestation in that county since that time.

In San Diego County several isolated instances of fairly effective work have been observed, but efforts to secure a general distribution and effectiveness over the entire infested area have not resulted satisfactorily. Repeated attempts to introduce this enemy into the valleys not immediately adjacent to the coast have uniformly resulted in failures. From these results it appears that there is very little hope for satisfactory results outside of certain limited areas near the coast, where the temperature and humidity conditions are more favorable for the development of the insect. One factor which prevents more effective work on the part of this predator is its inability, or at least lack of inclination, to spread to any extent from tree to tree, or from grove to grove. Infested trees have been found in which the beetles and their larvae were present in large numbers, and immediately adjoining these were other trees, also well infested, upon which practically none could be found.

The Green Lacewing (*Chrysopa californica* Coq.).—This delicate lacewing, while primarily an aphis feeder, is often found in considerable numbers in connection with mealy-bug infestations. Feeding is quite extensive by both larvae and adults, the younger stages of mealy bugs ordinarily being attacked. The eggs are small, ovoid, and light green in color and are attached to the end of a large stalk. The larvae hatch and immediately crawl about in search of food. The long, sickle-shaped jaws enable them to pierce the body of the mealy bug easily and to extract the body juices. At the time of pupation the larva forms a thin but very dense white cocoon about itself and undergoes its transformation. About this main pupal case is found ordinarily an indefinite fibrous web, which serves to hold it in place. The cocoons are usually placed in crevices in the bark, etc., but as a general rule are more exposed and conspicuous than those of the brown lacewing (*S. californicus* Banks).

Scymnus guttulatus Lec.—This minute, native coccinellid is restricted in distribution to the coast counties, and its work is confined largely to the mealy bugs, though feeding has been occasionally observed upon the young of the black scale. While no instances of satisfactory control under field conditions have come to our attention, yet, in connection with other parasites and predaceous enemies, the aggregate effect is often appreciable.

Scymnus bipunctatus Kugel.—The first introduction of this predator was brought about by George Compere from the Philippine Islands in 1910. It was introduced under the name of *Cryptogonus orbiculus*, and has been known as such since that time. Recent determinations by Smith,[5] however, give the identification as *S. bipunctatus*. Since 1910 a fairly general distribution throughout Ventura and Santa Barbara counties has been effected, though the numbers to be found are comparatively small. In certain foreign countries very effective work is reported for this species, and colonies recently established by Smith in California give promise of more satisfactory results than followed the first introduction.

Scymnus marginicollus Mann.—This native species is often found feeding upon the younger stages of the various mealy bug species, though its attacks are, in general, distributed over the entire group of scale insects. Increase in numbers under normal field conditions

[4] Childs, Leroy, Monthly Bulletin Cal. Hort. Com., Vol. III, No. 5, p. 220, May, 1914.

[5] Smith, H. S., Monthly Bulletin Cal. Hort. Com., Vol. III, No. 12, p. 535, December, 1914.

is not rapid, and because of the very small size of the individuals only a comparatively small number of eggs and larvae of the mealy bug are consumed by a single beetle.

Scymnus sordidus Horn.—Of the members of the genus *Scymnus* this species is the greatest in importance as an enemy of the mealy bug. In distribution it is restricted to a considerable extent to Ventura, Los Angeles, and Orange counties. In appearance the adults are dark brown in color, while the larvae are covered with the coating of waxy filaments characteristic of a large number of mealy bug feeders.

Chrysoplatycerous splendens How.—This hymenopterous parasite, on the basis of imperfect records as to its first appearance in this country, was introduced into California from the Philippine Islands by Compere. At that time it was placed only in San Diego County, but at the present time specimens may be found generally distributed in small numbers over all of southern California.

Miscellaneous.—Observed as occasional feeders upon the mealy bugs are the following coccinellids: *Chilocorus bivulnerus* Muls., *Hippodamia convergens* Guér., *Rhizobius lopanthae* Blaisd., *Rhizobius ventralis* Er., *Scymnus nebulosus* Lec., and *Novius cardinalis* Muls.

Determined as occasional predaceous enemies were: *Hemerobius pacificus* Banks, *Leucopus bellula* Will., *Baccha lemur* O. S., and several other syrphids.

Several internal parasites, as yet undetermined, were secured from *P. longispinus* Targ. at Pasadena and Santa Barbara. A small parasite of *P. citrophilus* at Uplands was determined by Mr. P. H. Timberlake as *Pseudaphycus angelicus* How.

THE CONTROL OF MEALY BUGS ON CITRUS TREES

FUMIGATION

Comparative Resistance of Species.—The study of fumigation with reference to the control of mealy bugs naturally gave rise to the question of the relative resistance of the various species to the effects of hydrocyanic acid gas. To determine this point, a series of laboratory experiments were conducted, in which a fumigatorium with a capacity of 25 cubic feet was used. Upon the basis of one ounce of sodium cyanide per 100 cubic feet, as a 100 per cent schedule, the amount to use in the box would be one-quarter of this, or 7.5 gm. cyanide with 11.2 c.c. sulfuric acid and 15 c.c. water, the 1, 1.5, 2 formula being

used. The dosages as given in the following table represent the percentage of the above amount used. The most resistant species of the four was found to be *P. citrophilus,* the larvae of which were all killed by a 70 per cent dosage, as compared with 60 per cent for *P. citri.* The eggs and adult females were the first to succumb to the effects of the gas, while the male pupae were the last killed. In connection with this table attention is called particularly to the fact that the conditions under which the experiment was carried out simulate in no way those found in actual practice, and, therefore, it should not be considered that the dosages given are in any degree correlated with field practices, in which leakage, size of trees, etc., are very important factors in the determination of the necessary amount of materials for use. The table is given only to indicate the relative mortality of the stages of the different species produced by a given amount of gas in an air-tight receptacle.

COMPARATIVE RESISTANCE OF SPECIES TO FUMIGATION

Figures in each case represent percentages

Capacity of fumigatorium, 25 cu. ft.

	Time of experiments, hour	Temperature, ° F.	40 per cent dosage	Temperature, ° F.	50 per cent dosage	Temperature, ° F.	60 per cent dosage	Temperature, ° F.	70 per cent dosage
P. citri									
Eggs	1	68	....	65	100	66	.....	64	.....
Larvae	1	68	92	65	81	66	100	64	.....
Male pupae	1	68	....	65	.....	66	71	64	100
Adult females	1	68	80	65	100	66	.....	64	.....
P. bakeri									
Eggs	1	68	....	65	100	66	.....	64	.....
Larvae	1	68	74	65	92	66	100	64	.....
Male pupae	1	68	....	65	61	66	100	64	.....
Adult females	1	68	86	65	100	66	79	64	100
P. citrophilus									
Eggs	1	68	....	65	100	66	.....	64	.....
Larvae	1	68	65	65	85	66	98	64	100
Male pupae	1	68	....	65	17	66	82	64	100
Adult females	1	68	57	65	91	66	100	64	.....
P. longispinus									
Larvae	1	68	89	65	100	66	.....	64	.....
Male pupae	1	68	....	65	87	66	100	64	.....
Adult females	1	68	94	65	100	66	.....	64	.....

General Orchard Experience.—A marked conflict in prevailing opinions among growers and investigators as to the effectiveness of fumigation against the mealy bug was brought out at the Emergency Fruit Growers' Convention held in Ontario, January 30, 1914. Some growers reported very satisfactory results from the use of a three-quarters to a full schedule, continued for a period of two hours, the tent being recharged at the end of the first hour. On the other hand, a number reported very unsatisfactory results with this method of treatment, even after several fumigations each season. Other growers even went to the extreme of doubling the dosage at each application, with the result that the trees and fruit were severely injured, though live mealy bugs still remained. During the past season considerable mealy bug fumigation has come under the observation of the writer, and in only one instance were the results secured thorough enough to compensate for the expense of the treatment. It will, therefore, be seen that upon the basis of present-day methods and practices fumigation is not to be recommended as a satisfactory means of control, even when repeatedly applied.

SPRAYING

On the basis of the results secured during the past season and previously, it is evident that the application of certain sprays was uniformly more satisfactory, both as regards cost and efficiency, than fumigation with hydrocyanic acid gas.

Nozzles.—Inasmuch as the force with which the spray strikes the mealy bug is one of the most important factors in spraying work, it is very evident that the mist spray nozzles are of very little value. A nozzle giving a well centered drive spray should be used. In the application of water alone, as later discussed, the M. A. C. nozzle was found to be very satisfactory. This nozzle was developed in Massachusetts for use against the gipsy moth. Under 200 pounds pressure, about five gallons of solution per minute is used, and any form of stream desired may be secured.

Kerosene Emulsion.—This spray is very commonly used in control work against various scale insects. The formula ordinarily used is as follows:

Kerosene (42° Baumé)	20 gals.
Solid whale oil soap	5 lbs.
or	
Liquid whale oil soap	1 gal.
Water	200 gals.

This emulsion is so well known as to require no directions for its preparations. It is quite effective against many scale insects when thoroughly applied; yet in the case of the mealy bug the results were not entirely satisfactory. The penetrating action of the spray was not great, it being necessary to remove the waxy covering of the mealy bugs by the force of application before an extensive killing could be secured. This lack of penetration is also a serious handicap in cases where large egg masses are present, it being evident that the killing only of those on the outer surface will have little effect in checking the infestation. However, if these masses are not present, and the bugs are present in only small numbers upon the fruit and foliage, satisfactory results may be looked for when the application is thoroughly made. Considerable care must be exercised in the use of this spray during the hot summer months, as a burning of the fruit may take place at a temperature above approximately 89° F., particularly if the humidity is low. In the coast sections, however, little trouble is experienced in this regard.

Distillate Emulsion.—The following formula gives the concentration ordinarily used in citrus spraying:

Distillate (32° Baumé)	4 gals.
Liquid whale oil soap	¾ gal.
or	
Solid soap	5 lbs.
Water	200 gals.

This emulsion is prepared in the same manner as that of kerosene and is often used in preference to that because of the lesser cost. Distillate spraying is much less likely to do injury to the fruit and foliage in the coast sections than in the interior sections.

Kerosene-Lime Mixture.—The formula is as follows:

Kerosene (42° Baumé)	20 gals.
Unslaked lime	40 lbs.
Water	200 gals.

In preparing the mixture the lime is gradually slaked in a barrel or other convenient receptacle and thoroughly mixed to a creamy consistency. For convenience in handling, a mixture of one pound of lime per gallon of water should be used. The necessary quantity of this material should then be strained and placed in the tank, the kerosene and sufficient water to cover the agitators added, and the engine started. Three or four minutes will be sufficient to bring about a thorough emulsification. In case the mixture is permitted to stand for some time, the lime and kerosene which it has absorbed will sink

to the bottom of the tank and a thin layer of frothy lime will appear on the surface. The emulsion, however, is stable and requires only agitation to be ready for use.

The use of lime as the emulsifying agent instead of soap was found to increase considerably the penetration of the waxy covering of the mealy bugs. Where large egg masses are found upon the fruit and twigs, the penetration will not be complete by the first application, but a thin crust of lime will be formed over the surface, which will prevent the exit of the young mealy bugs from the navels of the oranges. The white coating of lime deposited over the entire tree brought out strongly the fact that in field spraying as ordinarily practiced the uppermost branches in the center of the tree were very often left unsprayed, and as a result the possibilities of a rapid re-infestation were very good. The presence of some indicator in the spray is particularly desirable in mealy bug control work, where application to every portion of the tree is a prime necessity.

It is evident that a thorough washing or brushing of the fruit will be necessary following the application of this spray, and its use is, therefore, inadvisable where the infestation is not severe enough to require the washing when unsprayed. This emulsion has been found to be the most satisfactory and efficient of all "composition" sprays tested, and is to be recommended in cases of heavy infestation, in which for any reason the use of large quantities of water alone, as later discussed, is not possible.

Carbolic Acid Emulsion.—Varying results have been reported for this material as a mealy bug spray for many years, some claiming it to be very efficient and others insisting strongly that it is of very little value. The formula ordinarily used is as follows:

Crude carbolic acid	5 gals.
Liquid whale oil soap	8 gals.
or	
Solid whale oil soap	40 lbs.
Water	40 gals.

The soap should be added to the boiling water and the crude carbolic acid then poured in and allowed to boil for ten to twenty minutes. This stock solution should then be diluted with twenty parts of water for spraying purposes.

The number of infested trees treated by the writer with this emulsion was 142, and the results secured were decidedly negative; in fact, of all spray materials used this emulsion effected the least killing. Even though the wax was completely removed from the mealy

bugs by the force of the spray, many survived to continue the infestation.

A series of samples of crude carbolic acid were sent to Mr. G. P. Gray, chemist of the insecticide laboratory, for analysis. The specific gravity of these samples at 17.5° C. ranged from .920 to .965, while the total phenol content varied correspondingly from 1.2 per cent to 18.6 per cent. The ratio of increase, however, was not constant. The following comments by Mr. Gray are of interest: "The variation in these samples is no greater than might be expected in the purchase of crude carbolic acid as found on the market. Previous examination by this laboratory of a great many samples shows an even greater variation than the above, the range being from 4.5 to 38 per cent. . . . No uniformity of results can be expected from the crude carbolic acids and the coal tar creosotes as commonly produced in the United States. Most of the materials sold under the two above names appear to be mixed residues from coal tar refineries, which cannot be sold for any other purpose, and also are quite frequently mixed with petroleum distillates. I am not sure that the phenol is the most active agent in the control of the mealy bug."

In connection with the use of carbolic acid in the proportion given above, considerable burning of fruit occasionally takes place, and in some cases the acid odor and taste may be detected several months after its application.

Water.—The most efficient means of control for mealy bugs known at the present time is the application of large quantities of water under high pressure. In the investigations conducted by the writer, a total of 347 trees were sprayed with water under varying degrees of pressure and methods of application.

Under the direction of Horticultural Inspector A. G. Smith of Pasadena, several groves at that place were equipped with a complete piping system, this consisting of a one-inch underground pipe line along the head of the grove and three-quarter inch laterals leading down every fourth row. An ordinary garden hydrant was placed at every fourth tree, thus enabling the operator to reach every tree in the grove with a hose line 125 feet in length. In these particular cases the necessary power was secured from an ordinary power spray outfit near the irrigation hydrant, a float valve being used in connection with the intake hose to regulate the amount in the tank, and the water then pumped directly into the main pipe line under high pressure. The main argument against this system is the rather large initial cost of the equipment, which may possibly be needed for only one or two years, the degree of infestation varying greatly from year to year.

This has been well illustrated in Ventura County, where five years ago the attack of the pest was very severe, yet a general decline has taken place since then, and at the present time not so many groves are seriously enough infested to require control measures. It is, therefore, not recommended that this equipment be installed unless it may also be used for irrigation purposes, as is the case in certain localities, or where experience over a considerable period of years has shown that the pest will maintain itself in damaging numbers from year to year.

A modified form of this system and one which will materially reduce the cost of installation is the use of the long, sectional hose lines in place of the underground lateral pipe lines. Galvanized one-inch pipe may be used for the main line, the additional initial cost being well compensated for by the increased durability. Half-inch hose of the best quality should be used in sections of about 100 feet, with an occasional shutoff to facilitate the work. In the work in the field, the line should be run its full length down the rows and the trees at the lower end sprayed first. As a matter of convenience, not more than two rows on each side should be taken, and when a sufficient number have been sprayed a section of hose may be removed and the work thus continued up the rows. In case a regulation power sprayer is available, this may be used according to directions, as previously given. If the purchase of an outfit is necessary, however, it would be well to secure a standard pumping outfit of the required power rather than to go to the expense of securing the complete outfit. The methods of attachment and the position with reference to the water supply vary so greatly that no general directions can be given, and arrangements must be made to suit conditions existing in every grove.

The cost of installing the pipe system ranges from $15 to $25 per acre, while the cost of spraying after this time will total approximately $2.25 per day for every man's labor, and also the cost of running the engine. Allowing for twenty minutes' time in the spraying of every tree, this would cost about 15 cents per tree, which cannot be considered excessive.

Where the infestation is restricted to small areas, the use of the regulation spray outfit is the most economical and satisfactory. In connection with this, there should be a supply wagon for hauling water to the tank, as the time required in transit and in filling, where this is done with the tank itself, is wasteful, necessitating as it does the cessation of work by the engine and the men handling the hose lines. The large amount of material used makes this equipment very desirable.

In the application of water as a means of control too much emphasis cannot be laid upon the necessity of thorough application. The pressure with the M. A. C. nozzles should never be less than 175 pounds, while considerably higher pressure would be advantageous. The form of stream used should be such as to give a spread of not more than six or eight inches at a distance of six feet from the nozzle. The amount of water applied will naturally vary considerably with the size of the tree and the severity of the infestation. In the case of a medium-sized tree, 50 to 100 gallons is necessary to wash the tree thoroughly.

The treatment should be repeated as soon as the egg masses and adults begin to appear in any considerable numbers on the tree. The number of applications necessary will naturally vary with the degree of the infestation.

SUMMARY

1. Four species of mealy bugs feed upon citrus trees in Southern California—*P. citri, P. bakeri, P. citrophilus,* and *P. longispinus.*

2. By far the greatest amount of injury is caused by the common mealy bug (*Pseudococcus citri*).

3. The infestation at Uplands, California, was found to be caused by a new species, now designated as the citrophilus mealy bug (*Pseudocuccus citrophilus*).

4. The life history during the summer covers approximately two months, the egg stage requiring 8 to 10 days and the nymphal stages a total of about 50 days.

5. Maximum numbers are ordinarily found upon the trees during the early spring and late fall months.

6. The spread from one grove to another is effected upon picking boxes, pickers' clothing, cultivating tools, by birds, etc.

7. Parasites at the present time are not very effective in mealybug control, and their work should not be relied upon to the exclusion of artificial control methods where the infestation is serious.

8. Fumigation with hydrocyanic acid gas is not to be recommended.

9. The citrophilus mealy bug is more resistant to hydrocyanic acid gas than any of the three other species.

10. Spraying with water under high pressure, using the M. A. C. nozzle, is the most effective means of control, and when thoroughly done gives a considerable degree of success.

11. Treatment should be repeated whenever the injury produced by the insect becomes sufficient to warrant the expense.